Electrically Controlled Drug Release using Graphene Based Hydrogels

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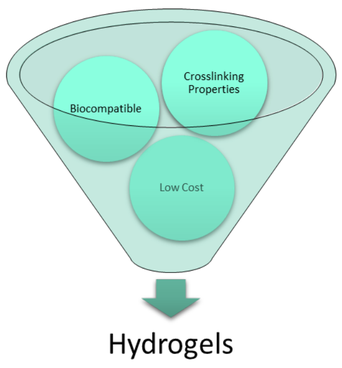
Abstract

The quest to understand drug delivery to a specific site, quantity, or time has led to various method of trying to control drug delivery. If controllable drug delivery is mastered, managing and treating diseases will improve dramatically. Liposomes, microsomes and hydrogel are currently been used for these purpose. Hydrogels with three dimensional network of hydrophilic polymers are being considered because of their biocompatibility, minimal mechanical irritation, low cost, and ability to crosslink. Electro-responsive hydrogels are now been favored as to others such pH, temperature and light stimulated hydrogel because of the availability of the equipment, precise control on the magnitude of current, intervals and duration of electric pulses. Incorporating graphene in this hydrogel can also in improving drug delivery

Introduction



Hydrogel's provide many benefits including low cost, low mechanical strength, and they can be made under mild conditions. Hydrogels are commonly used as a drug delivery method because they are easily produced and biocompatible due to the fact that it is structurally similar to the extracellular matrix. It is found that hydrogels cause minimal tissue damage making it a great candidate for drug delivery systems [1].

Figure 1: A schematic representation of the benefits of using hydrogels for controlled drug delivery systems**.**

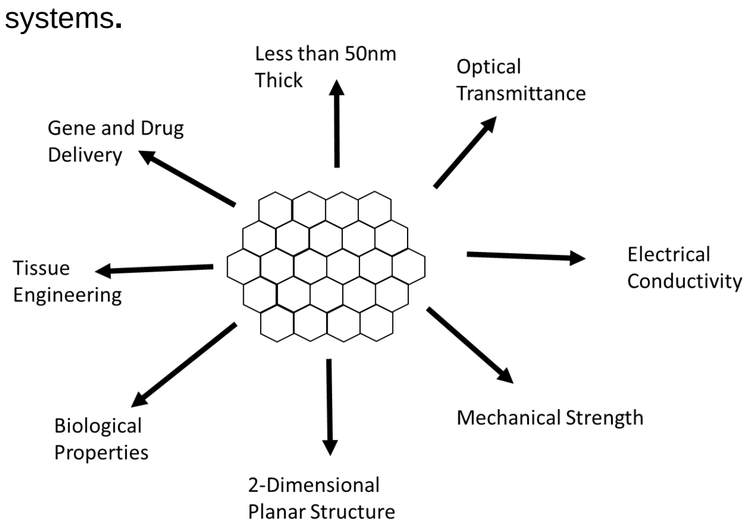


Figure 2: Schematic detailing of the properties, structure, and some well-known uses of graphene.

Graphene is a recent wonder material ever since winning the Nobel Prize in 2010 that researchers have found to be a good prospect for the controllable drug delivery system Graphene has many unique properties as detailed above. The mechanical properties make it a good candidate for drug delivery while the optical and electrical properties might make it easy to be controlled[2].

Method

All research was carried out at Dr. Patra's laboratory at the University of Bridgeport. First varying concentrations of a PVA borax hydrogel were created (4%, 6%, 8% and 10%). While some ratios caused the hydrogel to be too slurry, others created an extremely viscous mixture. A 6% PVA borax hydrogel was found to be ideal. Rhodamine B dye was incorporated into the hydrogel and then shortly after attached to a negative electrode and placed into a distilled water solution. Both forward and backward bias were done by applying a voltage of 100mV. At 30 minute intervals, the absorbance was measured on a UV spectrophotometer to measure the amount of drug released. It was found that the gel dissolved between 90 minutes to 120 minutes and as many time points as possible were tested. A control hydrogel was also completed with no dye. Future experiments plan to incorporate graphene as well as test a variety of other drugs.

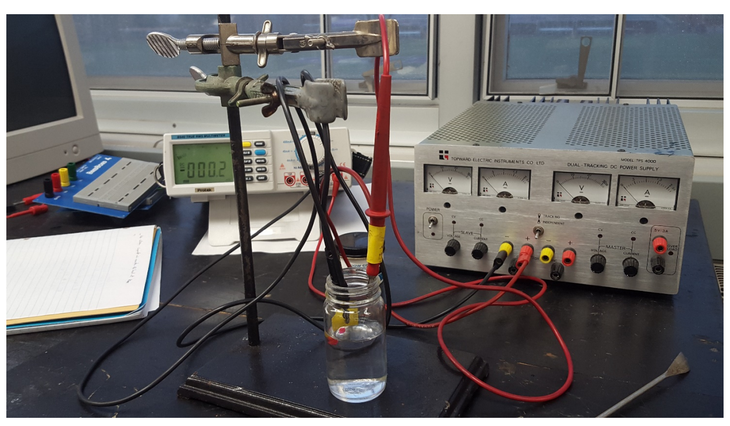


Figure 4: The setup for electrical control drug release.

Methods Continued …

A 6% PVA-Borax hydrogel were prepared and mixed in the ratio 10:1, two concentrations of 16.6%w/v of 0.1% and 0.001% of rhodamine was added to make the rhodamine loaded hydrogel. About 0.25g of the Rhodamine gel was then attached to the electrodes. Both forward and backward bias were done by applying a voltage of 100mv. At 30mins interval, Absorbance was taken to measure the amount of drug released. Each experiment was allow to run until the gel was completely dissolved in water (1.5-2hrs).For the control no voltage was applied to the Rhodamine gel.

Results & Discussion

TYPE OF GEL	HIGHLIGHTS OF THE STUDY
GO + HYDROGEL	GO concentration significantly increased in the presence of an organic solvent.
PAM + HYDROGEL	Modified Mechanical and thermal properties i.e. more conducive
PAM + BIS	Brittle and Weak.
BIS + GO	Good tensile properties and a reduction in pore size and an expansion in the gel matrix.
PAA + GRAPHENE	Successful crosslinking and potential for the drug delivery system.
ADR + GO	High drug Loading Capacity along with pH sensitivity
PEI + GO	Gene and drug were co delivered effectively. IT was also found to enhance anti-cancer activity.
TI+ GO + BMP2	Efficient carrier for therapeutic proteins

Table 1: A table detailing various graphene hydrogel combinations [2]. ADR=Adriamycin/doxorubicin PEI= polyethyleimine Ti= titanium BMP2= bone morphogenetic protein 2

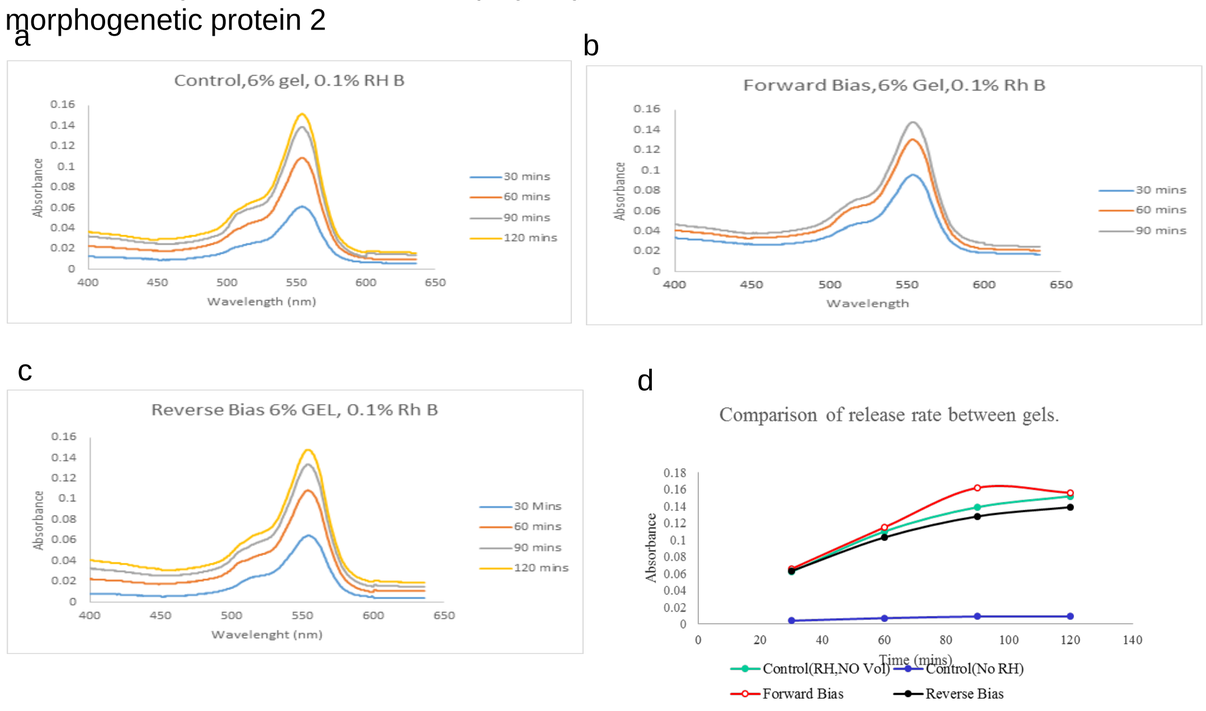


Figure 5: Graphs showing Electrically control release of Rhodamine dye- (a)Control gel, (b)Forward bias gel, (c) Reverse bias gel & (d) comparison of these gels.

Conclusion

Electrically stimulated controlled drug delivery was tested out and it was observed that the forward bias base controlled release of the dye works best. More experiment needs to be carried to further enhance his controlled release. If controllable drug delivery is able to be mastered then the results would change medicine. In the future a variety of potential drugs will be studied in depth. This will have massive clinical applications and also need to undergo major clinical trials. As can be seen in the figures above when using the rhodamine dye the release was able to be controlled electrochemically. The human body is constantly shifting electrochemically, an electrochemically controlled drug release could detect and fix the problem before doctors may even see the problem. The mechanism behind the bodies electrochemical control still needs to be further understood before this can be used. In the future a variety of drugs will be tested including doxorubicin andmethylene blue.

References

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